Power MOSFETs

IXYS Corporation
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I. Power MOSFETs: Key Parameters

- Drain-source breakdown voltage, $V_{DSS}$
- Continuous drain current, $I_{D(\text{cont})}$
- Drain-source On-resistance, $R_{DS(\text{on})}$
- Gate charge, $Q_g$
- Diode reverse-recovery time, $t_{rr}$
IXYS Power MOSFET Technologies

- Ultra Junction X-Class
- HiPerFET™
- TrenchT2™
- Very High Voltage
- Linear with Extended FBSOA
- Depletion Mode
- P-Channel
# IXYS MOSFET Advantages and Applications

<table>
<thead>
<tr>
<th>Product Family</th>
<th>Features/Advantages</th>
<th>Applications</th>
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</thead>
</table>
| **Ultra Junction X-Class**   | ▪ Low $R_{DS(on)}$ and gate charge  
▪ $dv/dt$ ruggedness  
▪ Avalanche rated  
▪ Low package inductance  
▪ International standard packages | ▪ Power Factor Correction Circuits  
▪ Switched-mode and resonant mode power supplies  
▪ DC-DC converters  
▪ AC and DC motor drives  
▪ Lighting control |
| **HiPerFET™ (Polar3™ and Q3-Class)** | ▪ Low $R_{DS(on)}$ and gate charge  
▪ High avalanche energy rating  
▪ Low thermal resistance  
▪ Low intrinsic gate resistance  
▪ Dynamic $dv/dt$ ratings  
▪ Simple drive requirements  
▪ High-speed switching | ▪ Solar inverters  
▪ Lamp ballasts  
▪ Laser drivers  
▪ Robotic and servo control  
▪ Industrial machinery  
▪ Medical equipment  
▪ Switched-mode power supplies  
▪ E-bikes |
| **GigaMOS™ Trench/TrenchT2™** | ▪ High current capability  
▪ Low $R_{DS(on)}$  
▪ Avalanche capability  
▪ Fast intrinsic diodes | ▪ Synchronous rectification  
▪ DC-DC converters  
▪ Battery chargers  
▪ SMPS and UPS  
▪ Motor drives  
▪ DC choppers |
## IXYS MOSFET Advantages and Applications

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<th>Product Family</th>
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<tbody>
<tr>
<td><strong>LinearL2™ with extended FBSOA</strong></td>
<td>▪ High power in linear mode operation&lt;br&gt;▪ Guaranteed FBSOA at 75°C&lt;br&gt;▪ Avalanche rated&lt;br&gt;▪ Low static drain-to-source on resistance</td>
<td>▪ Current sources&lt;br&gt;▪ Circuit breakers&lt;br&gt;▪ Linear regulators&lt;br&gt;▪ Soft-start applications&lt;br&gt;▪ Programmable loads</td>
</tr>
<tr>
<td><strong>Depletion Mode D2™</strong></td>
<td>▪ ‘Normally-On’ operation&lt;br&gt;▪ Low $R_{DS(on)}$&lt;br&gt;▪ Linear mode tolerant&lt;br&gt;▪ Useable body diode&lt;br&gt;▪ Fast switching</td>
<td>▪ Current regulation&lt;br&gt;▪ Solid-state relays&lt;br&gt;▪ Level shifting&lt;br&gt;▪ Active loads&lt;br&gt;▪ Start-up circuits</td>
</tr>
<tr>
<td><strong>High Voltage and Very High Voltage</strong></td>
<td>▪ High blocking voltage&lt;br&gt;▪ Proprietary high-voltage ISOPLUS™ packages&lt;br&gt;▪ Up to 4500V electrical isolation (DCB)&lt;br&gt;▪ UL 94 V-0 Flammability qualified (molding epoxies)</td>
<td>▪ Capacitor discharge circuits&lt;br&gt;▪ High-voltage power supplies&lt;br&gt;▪ Pulse circuits&lt;br&gt;▪ Laser and X-ray generation systems&lt;br&gt;▪ Energy tapping applications from the power grid</td>
</tr>
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# IXYS MOSFET Advantages and Applications

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<th>Product Family</th>
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<tr>
<td><strong>P-Channels</strong></td>
<td>▪ Fast intrinsic diode</td>
<td>▪ Load switches</td>
</tr>
<tr>
<td><em>(TrenchP™ and PolarP™)</em></td>
<td>▪ Dynamic dv/dt rated</td>
<td>▪ High-side switches</td>
</tr>
<tr>
<td></td>
<td>▪ Avalanche rated</td>
<td>▪ DC-DC converters</td>
</tr>
<tr>
<td></td>
<td>▪ Rugged PolarP™ process</td>
<td>▪ Switching power supplies</td>
</tr>
<tr>
<td></td>
<td>▪ Extended FBSOA</td>
<td>▪ Battery chargers</td>
</tr>
<tr>
<td></td>
<td>▪ Low gate charge and $R_{DS(on)}$</td>
<td>▪ Current regulators</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Automatic test equipment</td>
</tr>
</tbody>
</table>
$R_{DS(on)}$ vs. Blocking Voltage

- Standard P-channel (-50V to -600V)
- Q3-Class
- Polar™
- Polar2™
- Polar3™
- Ultra Junction X-Class
- GigaMOS™ Trench/TrenchT2™

Blocking Voltage (V) vs. $R_{DS(on)}/\text{mm}^2$
MOSFET Switching Frequency vs Blocking Voltage

Discrete MOSFETs

Fsw vs Blocking Voltage

- Q3-Class HiPerFET™
- Polar™ Series (Standard & HiPerFET™)
- Depletion Mode D2™
- Super Junction X-Class
- Linear/LinearL2™
- GigaMOS™ Trench/TrenchT2™
- Very High Voltage

MOSFET Switching Frequency vs Blocking Voltage

Fsw
0 50 75 100 300 600 900 1200 1700 2500 4000

Blocking Voltage
0 50 75 100 300 600 900 1200 1700 2500 4000 5000

- 2 MHz
- 1 MHz
- 500 kHz
- 100 kHz
- 40 kHz
- 10 kHz
- 5 kHz
- 1 kHz

IXYS
Competitive Landscape: Discrete Power MOSFETs

- Very few to no competitors above 1700V!
- Closest competitor offers only up to 1700V
## II. Power MOSFET Product Lines

<table>
<thead>
<tr>
<th>MOSFET Technology</th>
<th>$V_{DSS}$ Voltage</th>
<th>$I_{D25}$ Current at 25°C</th>
<th>$R_{DS(on)}$ (max) On-resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N-Channels</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultra Junction X2-Class</td>
<td>650V</td>
<td>2A – 150A</td>
<td>17mΩ</td>
</tr>
<tr>
<td>HiPerFET™ (Polar™, Q3-class)</td>
<td>70V - 1200V</td>
<td>0.7A – 340A</td>
<td>4mΩ - 4.5Ω</td>
</tr>
<tr>
<td>GigaMOS™ Trench/TrenchT2™</td>
<td>40V - 300V</td>
<td>12A - 600A</td>
<td>1mΩ - 85mΩ</td>
</tr>
<tr>
<td>Linear with Extended FBSOAs</td>
<td>75V - 1500V</td>
<td>2A - 200A</td>
<td>11mΩ - 15Ω</td>
</tr>
<tr>
<td>Depletion mode</td>
<td>100V - 1700V</td>
<td>0.2A - 20A</td>
<td>64mΩ - 80Ω</td>
</tr>
<tr>
<td>Standard (high voltage, very high voltage)</td>
<td>55V - 4500V</td>
<td>0.1A - 250A</td>
<td>7.5mΩ - 625Ω</td>
</tr>
<tr>
<td><strong>P-Channels</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TrenchP™</td>
<td>-50V to -200V</td>
<td>-10A to -210A</td>
<td>7.5mΩ - 0.35Ω</td>
</tr>
<tr>
<td>PolarP™</td>
<td>-100V to -600V</td>
<td>-10A to -170A</td>
<td>12mΩ - 1Ω</td>
</tr>
<tr>
<td>Standard</td>
<td>-85V to -600V</td>
<td>-8A to -50A</td>
<td>55mΩ - 1.2Ω</td>
</tr>
</tbody>
</table>
### III. Latest Power MOSFETs

- 500V-600V Polar3™ HiPerFETs™
- 200V-1000V Q3-Class HiPerFETs™
- 1000V/30A Q3-Class HiPerFETs™ in SMPD package
- 2000V, 2500V, 3000V MOSFETs
- 4500V MOSFETs
- 650V Ultra Junction X2-Class MOSFETs
500V-600V Polar3™ HiPerFET™ Power MOSFETs
(4A – 132A)

Energy efficient. Reliable.

FEATURES
- Low $R_{DS(on)}$ and $Q_g$
- Low thermal resistance $R_{thJC}$
- High power dissipation
- Dynamic $dv/dt$ ratings
- Avalanche Rated

ADVANTAGES
- Simple drive requirements
- Enables high speed switching
- Reduced component count & circuit complexity
- Cooler device operation

APPLICATIONS
- SMPS/RMPS, UPS, PFC, DC-DC converters, laser drivers, battery chargers, motor drives, solar inverters, lamp ballasts, robotic and servo control

Part number example:
IXFH60N50P3
“F” denotes HiPerFET™
“P3” denotes 3rd generation Polar series
200V-1000V Q3-Class HiPerFET™ Power MOSFETs (10A – 100A)

**IXYS’ latest generation of double metal power MOSFETs! Extremely fast and rugged design!**

**FEATURES**
- Low $R_{DS(on)}$ and gate charge $Q_g$
- Low intrinsic gate resistance
- High avalanche energy rating
- Excellent $dv/dt$ performance
- Fast intrinsic rectifier

**ADVANTAGES**
- High Power Density
- Easy to mount
- Space savings

**APPLICATIONS**
- SMPS, PFC, solar inverters, server and telecom power systems, arc welding, induction heating, motor controls

**Part number example:**
IXFX32N100Q3
“F” denotes HiPerFET™
“Q3” denotes 3rd Generation Q-Class
1000V/30A Q3-Class HiPerFET™ Power MOSFET in SMPD Technology

More Power, Less Package (ultra-low profile, energy efficient, and rugged)

**Features:**
- Low $R_{DS(on)}$ and gate charge $Q_g$
- Low intrinsic gate resistance
- Fast intrinsic rectifier
- Excellent $dv/dt$ performance
- High avalanche energy rating
- High power density

**SMPD Advantages:**
- Ultra-low and compact package profile
- 5.3mm height x 24.8mm length x 32.3mm width
- Surface mountable via standard reflow process
- 4500V ceramic isolation (DCB)
- Very high power cycling capability
- Excellent thermal performance
- Low package weight (8g)

**Applications:**
- DC-DC converters
- Battery chargers
- Switching and resonant power supplies
- DC choppers
- Temperature and lighting controls

**Part number:**
MMIX1F44N100Q3
Prefix “MMIX” denotes SMPD package
“F” denotes HiPerFET™
“Q3” denotes 3rd generation Q-Class
2000V, 2500V, 3000V Power MOSFETs

(0.2A-5A)  

For high voltage power conversion systems

FEATURES
- High blocking voltage
- Proprietary high-voltage packages

ADVANTAGES
- High power density
- Space savings (eliminates multiple series-connected devices)
- Easy mounting

APPLICATIONS
- Capacitor discharge circuits
- High voltage power supplies
- Pulse circuits
- Laser and X-ray generation systems
- High voltage relay disconnect circuits

Part Numbers
- IXTH1N200P3
- IXTH1N200P3HV
- IXTA1N200P3HV
- IXTH02N250
- IXTF1N250
- IXTT1N250HV
- IXTX5N250
- IXTT1N300P3HV
- IXTH1N300P3HV

“HV” denotes high-voltage package
4500V Power MOSFETs (200mA – 2A) *Ideal for very high voltage power conversion applications*

**FEATURES**
- High blocking voltage
- Proprietary high-voltage ISOPLUS™ packages
- Up to 4500V electrical isolation (DCB)
- UL 94 V-0 Flammability qualified (molding epoxies)

**ADVANTAGES**
- High power density
- Space savings (eliminates multiple series-connected devices)
- Easy mounting

**APPLICATIONS**
- Capacitor discharge circuits
- High voltage power supplies
- Pulse circuits
- Laser and X-ray generation systems
- High voltage relay disconnect circuits
- Energy tapping applications from the power grid

**Part Numbers**
- IXTT02N450HV
- IXTF1N450
- IXTH1N450HV
- IXTL2N450
650V Ultra Junction X2-Class Power MOSFETs
(2A – 120A)

**Features**
- Low $R_{DS(on)}$ and gate charge $Q_g$
- $dv/dt$ ruggedness
- Avalanche rated
- Low package inductance
- International standard packages

**Advantages**
- High efficiency
- High power density
- Easy to mount
- Space savings

**Applications**
- PFC circuits, switched-mode and resonant-mode power supplies, DC-DC converters, AC and DC motor drives, robotic and servo controls, lighting control

**Part number example:**
IXTH34N65X2
“X2” denotes Ultra Junction X2-Class
- IXTP2N65X2
- IXTY4N65X2
- IXTH12N65X2
- IXTK120N65X2

*Ideal for Power Factor Correction (PFC) applications!*